

PRACTICAL CIRCUITS FOR COLOR TELEVISION

Part 1. R-F, I-F and Video Amplifier Circuits

This issue of the Du Mont Service News constitutes the first of a series of articles describing how the color television signal is processed by the receiver circuits. Although much of the information that follows applies to color receivers in general, the circuit descriptions are based on circuits used by Du Mont.

Figure 1 shows the color television receiver in block diagram form with signal paths indicated by arrows. As shown, the signal progresses through the r-f tuner, i-f amplifier, video detector and video amplifier circuits in the same manner as in a black and white receiver. The sound system also is the same as in the black and white

receiver except that the sound takeoff point is ahead of the video detector. In conventional intercarrier monochrome receivers, the sound and video carriers are mixed in the video detector to obtain the 4.5 mc sound signal. Since the sound take-off point in the color receiver is ahead of the video detector, a crystal detector is included

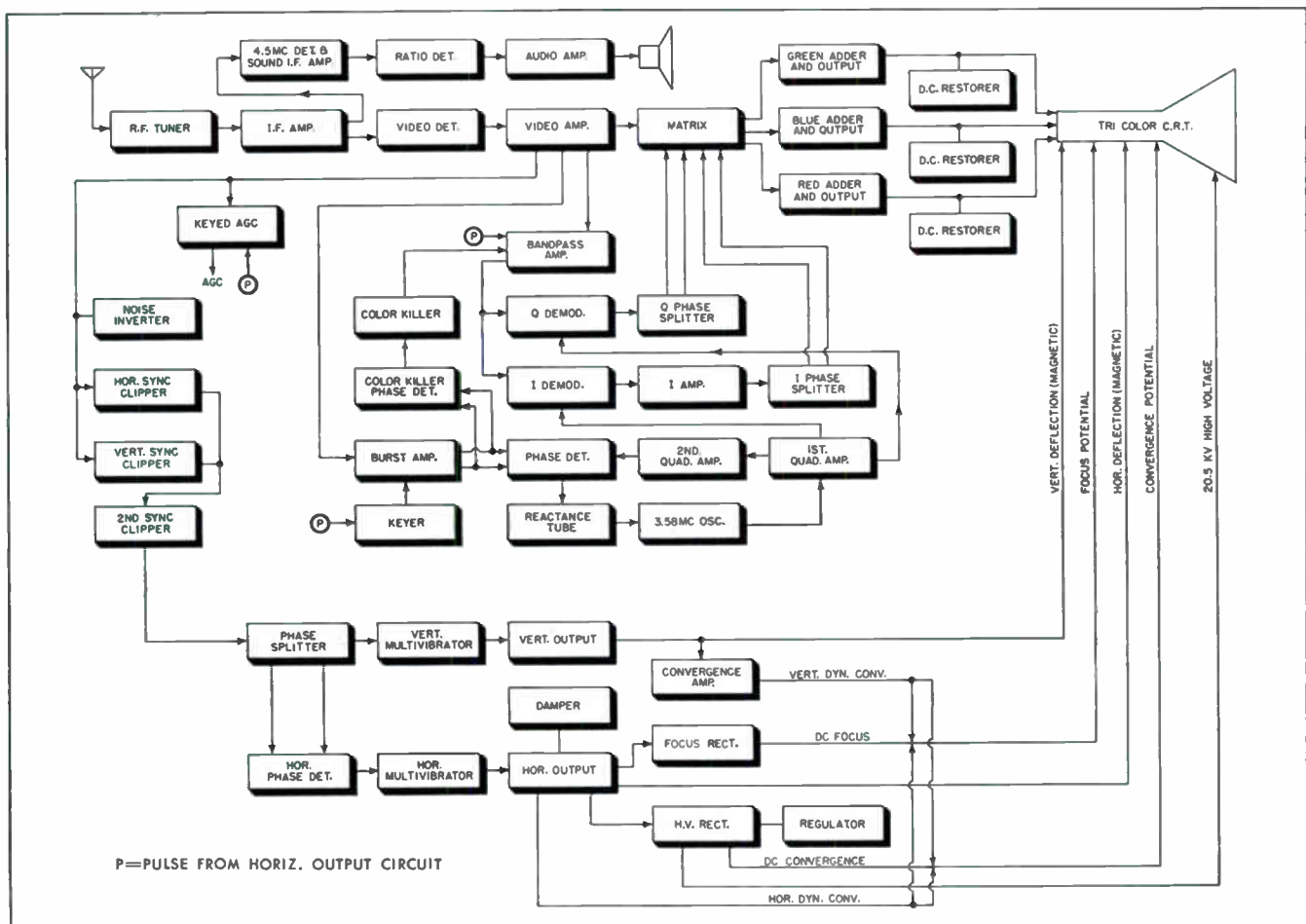


Figure 1. Block diagram of a color television receiver showing signal paths.

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as part of the sound system to derive the 4.5 mc beat signal.

The keyed a.g.c. circuit and the sync circuits operate in the same manner as their black and white counterparts. The sweep circuits too provide deflection voltages in the same manner as in the black and white receiver. However, the sweep output circuits are more complex due to the need for dynamic convergence voltages which are superimposed on the d.c. focus and d.c. convergence potentials. The high voltage circuit also is more complex in the color receiver as a result of higher potential and better regulation requirements.

The main differences between a monochrome and a color receiver are in the circuits not yet mentioned which appear in figure 1. These circuits can be divided into four basic sections: the matrix section, the chrominance channel, the color sync section, and the color killer. Included in the matrix section are the matrix itself, the color adder and output amplifiers, and the

d.c. restorer circuits. The chrominance channel includes the bandpass amplifier, I and Q demodulators, I amplifier, and I and Q phase splitters. Circuits comprising the color sync section are the burst amplifier, keyer, phase detector, reactance tube, 3.58 mc oscillator, and quadrature amplifiers. The color killer and its phase detector make up a circuit which disables the chrominance channel when a black and white signal is being received.

By studying the individual circuit descriptions that follow and using the block diagram shown in figure 1 to establish the circuit locations in regard to the overall receiver operation, the reader can gain a good working knowledge of the color television receiver.

R-F Tuner — Since the circuits of the r-f tuner in a color receiver are basically the same as in a monochrome receiver, it is not considered desirable to reproduce a tuner schematic on these pages. An item of great importance is the necessity of a full 6 mc bandwidth in the r-f circuits and a response curve that is as flat as possible. This is obtained through proper design and careful alignment using conventional techniques.

Figure 2 shows a typical response curve of the r-f circuits when tuned to channel 3. It can be seen that excessive dip at the center of the bandpass or low response at the high frequency end would result in attenuation of the 3.58 mc subcarrier and the color information. Such attenuation,

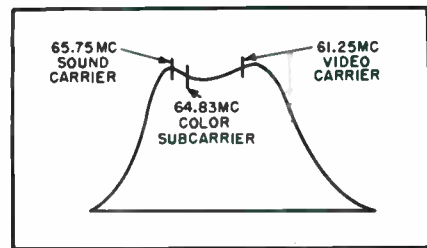


Figure 2. Tuner response curve for channel 3.

even if it were not sufficient to produce noticeable ill effects in the average black and white receiver, could result in improper color reproduction.

AGC voltage is applied in the conventional manner to the r-f amplifier stage.

Video I-F Amplifier — Although it is true that the video i-f amplifier in a color receiver performs the same function as its counterpart in the black and white receiver, several significant circuit differences exist. One difference is in the number of tubes employed. At the present time the average monochrome receiver uses three or four video i-f stages, while the average color receiver contains four or five. Additional stages are required to provide sufficient i-f gain with the wider bandpass needed for color reception. The color subcarrier is 3.58 mc and the upper sideband extends 500 kc higher in frequency. Therefore the minimum permissible bandpass for a color i-f amplifier is 3.58 mc + .5 mc or 4.08 mc. In addition approximately 120 kc should be allowed for tuning variations, bringing the total bandpass to 4.2 mc.

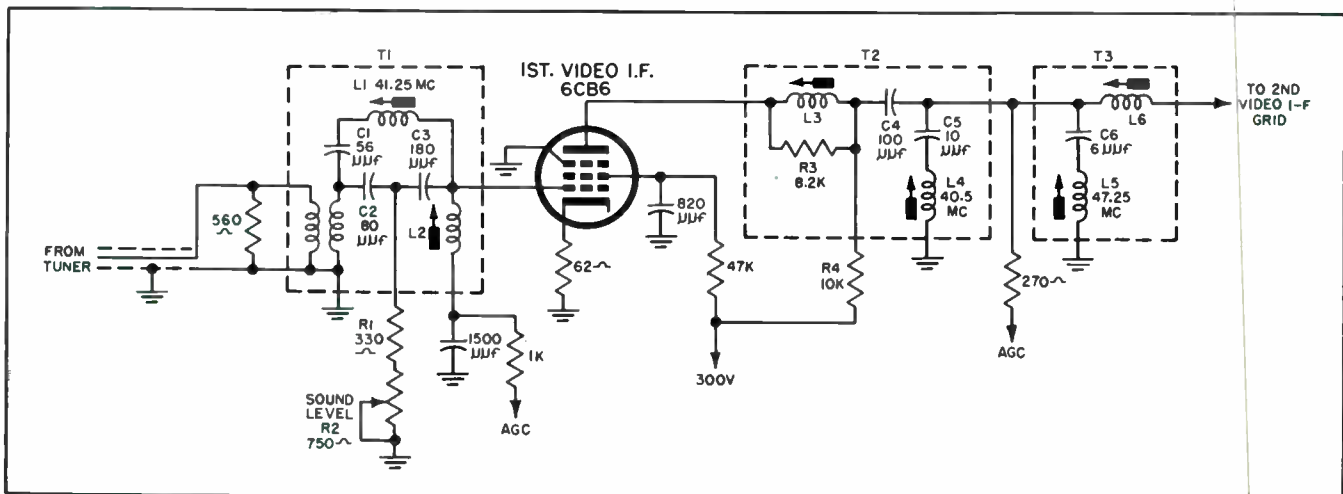


Figure 3. 1st video i-f amplifier circuit of a color receiver.

To obtain the required bandpass characteristics, some circuits are used which would be considered unusual in a monochrome receiver. For example, refer to figure 3 and observe the input circuit (T1) of the 1st video i-f amplifier. As shown the circuit includes the input coupling transformer, a peaking coil, and a 41.25 mc accompanying sound trap with provisions for varying the sound attenuation. The input transformer and the peaking coil are conventional, but the sound trap design is somewhat unusual.

Considering first the purpose of the trap and its associated sound level control, it should be noted that the sound i-f carrier (41.25 mc) and the color subcarrier i-f (42.17 mc) are separated by only 42.17 mc - 41.25 mc or 920 kc. If both signals reached the video detector without attenuation, a 920 kc beat signal would be developed, resulting in picture interference. The amplitude of the sound i-f carrier must be reduced to minimize this interference. The 41.25 mc trap circuit provides the necessary attenuation. Under conditions where the sound signal reaching the receiver is weak, it may be desirable to adjust the amplitude of the sound i-f carrier for the best compromise between sound reproduction and 920 kc beat interference on the picture. This adjustment can be made using the sound level control, which varies the degree of attenuation in the trap.

Attenuation of the 41.25 mc signal

in the sound trap is obtained by a voltage cancellation process involving phasing. A 41.25 mc resonant circuit is formed by C1, C2, C3 and L1 on figure 3. Inspecting the circuit, it can be seen that two paths exist between the secondary of the input transformer and the grid of the 1st video i-f tube; one path is formed by C1 and L1 in series, and another is formed by C2 and C3 in series. Since the path through C1 and L1 is predominately inductive, the phase change through this branch is such as to cause the voltage to *lead* the current. The path through C2 and C3 is capacitive, causing the voltage to *lag* the current. As a result, two voltages of opposing phase appear at the grid of the tube, and cancellation results.

The two voltages would not be in exact phase opposition if the sound level control, R2, and its series resistor, R1, were omitted from the circuit. Insertion of this resistance results in a change in the phase shift through C2 and C3. Maximum attenuation results when R2 is adjusted so that the phase shift through C2 and C3 is exactly opposite to the phase shift through C1 and L1.

At frequencies other than 41.25 mc, the effect of C1 and L1 is negligible, and C2 and C3 serve as coupling capacitors.

The coupling network between the plate of the 1st video i-f amplifier and the grid of the 2nd video i-f

plifier is not as unusual as it might appear at first glance. The output capacitance of the 1st video i-f amplifier tube and the plate inductance, L3, form a series resonant circuit. Since maximum current flow occurs at the resonant frequency in such a circuit and the flow is through the plate load resistor, R4, maximum voltage is developed across R4 at the resonant frequency. Off-resonance signals produce less current flow through R4 and consequently less voltage is developed across the resistor. Thus the result is basically the same as though a conventional parallel tuned circuit were employed. R3 reduces the Q of L3, broadening the response of the circuit.

The voltage developed across R4 is capacitively coupled through C4 to the tuned grid circuit of the 2nd video i-f amplifier. In the grid circuit, L6 and the input capacitance of the 2nd video i-f amplifier form another series resonant circuit through which maximum current flows at resonance. Under this condition, maximum voltage is developed across the high reactance represented by the input capacitance of the tube.

Two traps are included as part of the interstage coupling network. One trap, L4 and C5, is tuned to 40.5 mc which is between the adjacent picture (39.75 mc) and accompanying sound (41.25 mc) i-f carriers. It provides the desired bandpass shape factor and attenuation in this region. The other

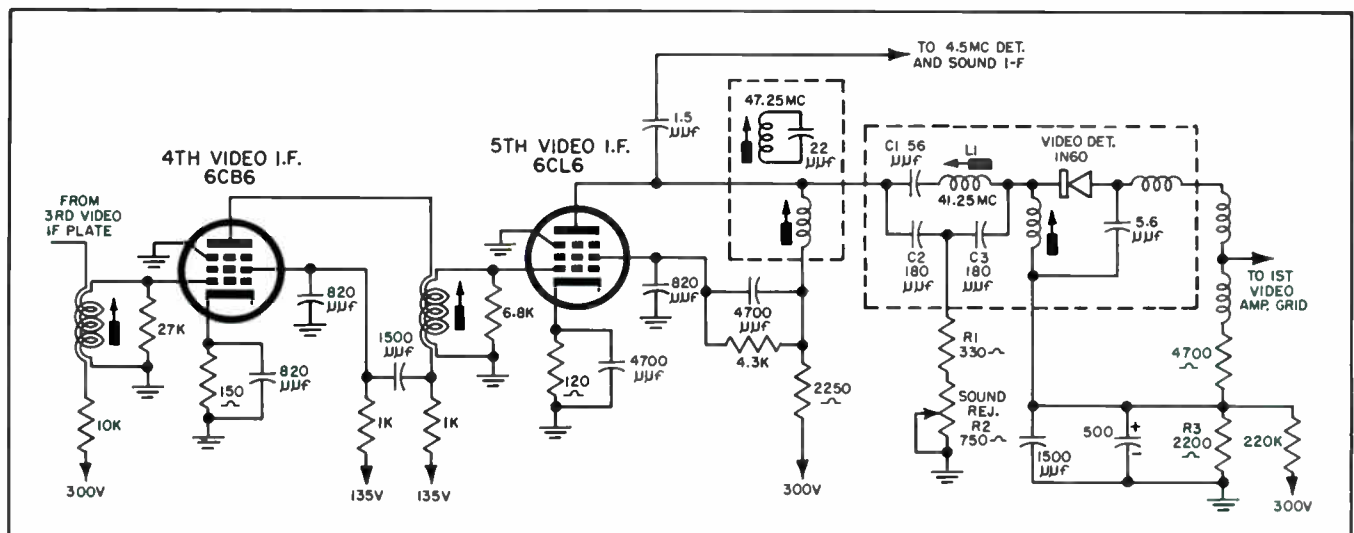


Figure 4. 4th and 5th video i-f amplifiers and video detector used in a color receiver.

trap, L5 and C6, is tuned to 47.25 mc to attenuate the adjacent sound carrier. These traps are simply series resonant circuits which offer a very low impedance at resonance.

The 2nd and 3rd video i-f amplifier stages are similar to the 4th stage which is shown in figure 4. As indicated the coupling transformers consist of bifilar coils. The transformers are stagger tuned to provide the desired overall response which is shown in figure 5.

Additional sound i-f carrier attenuation is required between the 5th video i-f stage and the video detector to minimize 920 kc beat interference in the picture. This attenuation is provided by C1, C2, C3, L1, R1 and R2 (figure 4) which form a 41.25 mc trap circuit exactly like the previously described trap located in the grid circuit of the 1st video i-f amplifier. The sound rejection control, R2, serves to adjust the phasing for cancellation of the sound carrier. This control should always be adjusted for maximum 41.25 mc attenuation because it has no effect on the sound system.

The sound i-f carrier level at the video detector is so low that satisfactory sound reproduction could not be obtained by locating the sound takeoff point after the video detector in the conventional manner. Accordingly, the sound is taken off at the plate of the 5th video i-f stage as indicated on figure 4, and a separate detector is used to derive the 4.5 mc sound signal as described later.

Video Detector — As shown in figure 4, the video detector circuit is conventional. So far as d-c is concerned, the 1N60 crystal is floated above ground by the few volts developed across R3. This does not affect the video detector operation, however — the purpose of the voltage is to properly bias the 1st video amplifier stage.

Sound System — The signals at the plate of the 5th video i-f amplifier are applied through C1 (figure 6) to the 4.5 mc detector circuit. The 4.5 mc beat between the video and sound carriers is detected by the 1N60 crystal and appears across the 4.5 mc tuned coil, L1.

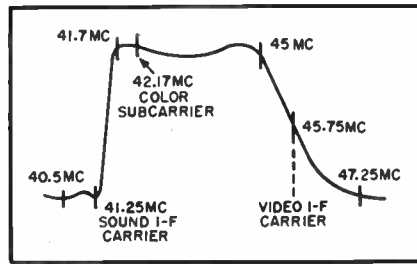


Figure 5. Overall video i-f response curve for color television.

From this point on, the sound system is the same as in the conventional monochrome receiver. Two stages of sound i-f amplification are used to provide adequate drive to a 6AL5 ratio detector. The audio signal recovered in the ratio detector is applied to a conventional sound system consisting of a voltage amplifier and a power output amplifier.

1st Video Amplifier—In addition to amplifying the video signal for application to the 2nd video amplifier, the 1st video amplifier serves as a signal distribution center. It provides a 3.58 mc burst signal to the burst amplifier, chrominance information (2 - 4.1 mc) to the bandpass amplifier, and composite video information to the sync and a.g.c. circuits.

As shown in figure 7 the composite video signal at the output of the video detector is applied to the grid of the 1st video amplifier. Direct coupling is employed, resulting in excellent low frequency response. High frequency compensation is provided by the shunt peaking coil, L1. A positive potential of approximately 3 volts is applied to the grid of the 6CL6 by the voltage divider, R1 and R2. This bias partially

counteracts the cathode bias developed across R3 and provides for linear operation of the tube.

The 4.5 mc trap in the cathode circuit of the 1st video amplifier represents a high impedance at 4.5 mc and a low impedance at other frequencies. This causes the 6CL6 circuit to be highly degenerative at 4.5 mc, resulting in attenuation of any 4.5 mc sound signal that may be present.

The signal voltage developed across R3 in the 6CL6 cathode circuit is applied across the color contrast control, R4, which serves to adjust the amplitude of the signal fed to the bandpass amplifier. Since this is the signal that supplies information to the chrominance channel, all signal frequencies between 2 and 4.1 mc must be included.

When a black and white transmission is being received, a d-c voltage is developed in the color killer circuit and applied to the bottom of the color contrast control. This voltage, applied through the arm of the control to the bandpass amplifier grid, biases the bandpass amplifier beyond cut off, preventing the chrominance channel from causing picture interference. However, the d-c voltage does not affect the video amplifier circuit, so the brief mention made here will suffice for the present. A complete description of the color killer operation will follow in a later issue.

The plate load circuit of the 1st video amplifier consists of a 3.58 mc trap, two resistors and an inductance. As a result of the high load impedance offered by the 3.58 mc trap, the 3.58 mc burst signal is of considerable am-

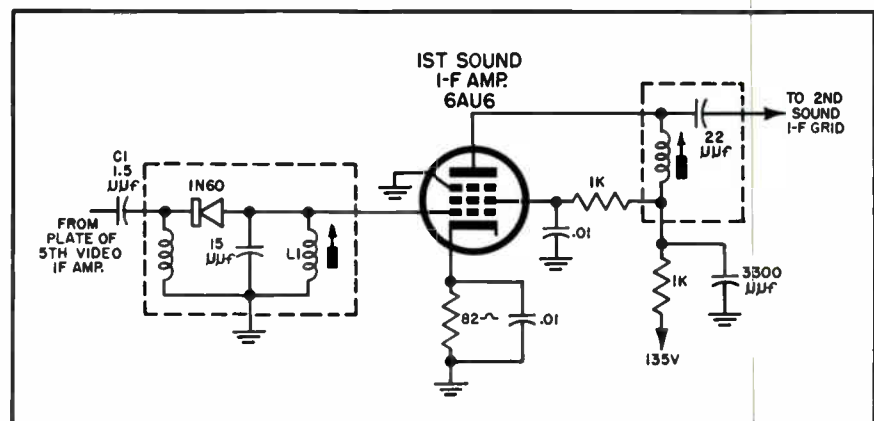


Figure 6. 4.5 mc detector and 1st sound i-f amplifier.

plitude at the plate of the tube. This signal is coupled from the plate of the 6CL6 to the burst amplifier and utilized to synchronize the chrominance circuits.

Because the 3.58 mc trap represents a high impedance to the 3.58 mc signal, practically all of the 3.58 mc signal voltage in the 6CL6 plate circuit is developed across the trap and only a negligible amount appears across the remainder of the load impedance. At other frequencies, however, the trap presents a low impedance and the signal voltages are then developed across the remainder of the load circuit. Thus the signal at the junction of R5 and the trap is a faithful reproduction of the original video signal up to approximately 3.2 mc (frequencies above 3.2 mc are attenuated by the 3.58 mc trap). This signal is applied to the sync and keyed a-g-c circuits.

The same signal which appears at reduced amplitude across R6 and L2 is applied through the delay line to the input circuit of the 2nd video amplifier. The resistance of R6 (2.7K) is correct to match the impedance of the delay line.

Delay Line — To understand the need for a delay line such as is used between the 1st and 2nd video amplifiers, it must be realized that the

time required for a signal to pass through a *wide* bandpass circuit is less than the time required for a signal to pass through a *narrow* bandpass circuit.

Figure 8 illustrates a low pass filter in basic form. The cut-off frequency, which is the highest frequency that will pass through the circuit without appreciable attenuation, is determined by the product of L and C; the larger the LC product, the lower the cut-off frequency and vice versa. Therefore, wide bandpass circuits have low LC products, and narrow bandpass circuits have large LC products.

Also shown in figure 8 is the relationship that exists between the input and output voltages in such a filter. It can be seen that the build up of the output voltage is delayed with respect to the input voltage. This is so because time is required to charge the capacitor, and the charging current is delayed in the inductance. The charging time increases with C, and the delay in the inductance increases with L. Consequently, it can be said that the time delay in a filter is roughly proportional to the LC product.

From this it can be seen that narrow band filters which have large LC products delay the signal more than wide band circuits which have small LC products. Since the chrominance

channel filter circuits restrict the bandwidth to .5 mc for the Q signal and 1.5 mc for the I signal, more time is required for the signal to pass through these circuits than is required for passage through the video amplifier which has a bandwidth of approximately 3.2 mc.

If delay lines were not incorporated to equalize this time differential, the I, Q and Y signals would arrive out of step at the matrix, resulting in incorrect reproduction at boundaries between colors. Accordingly, a delay line is included in the video amplifier to delay the brightness signal by an amount equal to the inherent delay in the narrow band (.5 mc) Q channel. Additional delay is also built into the 1.5 mc I channel to make the total delay through this channel equal

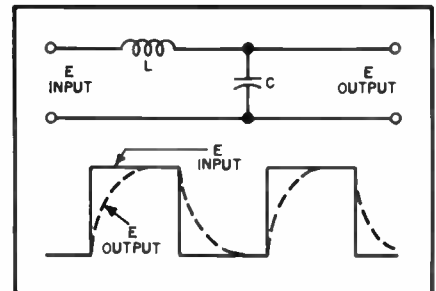


Figure 8. Simple low-pass filter circuit with input and output voltages shown to illustrate delay characteristic.

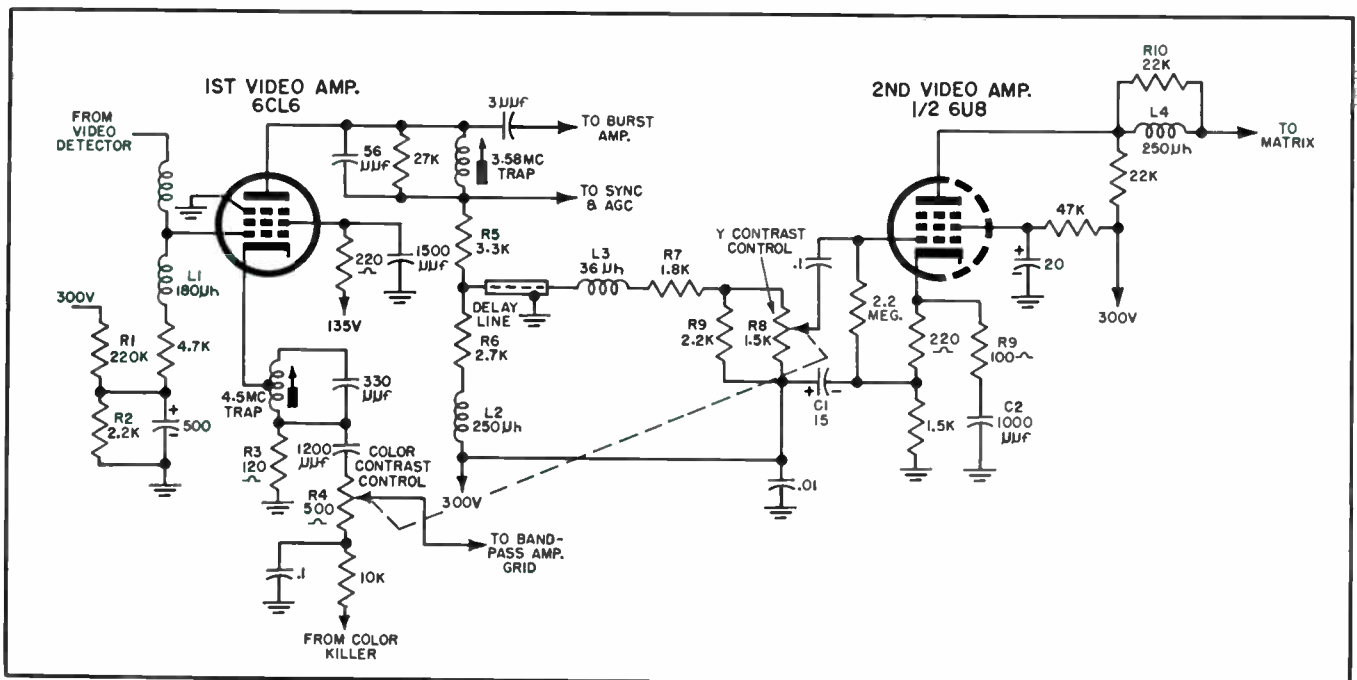


Figure 7. Video amplifier stages of a color receiver.

that of the Q channel, insuring simultaneous arrival of the three signals at the matrix.

A term "velocity of propagation" is commonly associated with transmission lines. This term takes into account the fact that signals take longer to travel a given distance through a transmission line than they do in free space. In other words, a transmission line delays the signal. The delay line in the video amplifier utilizes this principle. Using conventional transmission lines, even RG-59/U and similar types which have a velocity factor of approximately .66, excessive length would be required to obtain the desired delay of approximately one microsecond. Accordingly, the effectiveness of the cable for delay purposes is greatly increased by winding the center conductor in helical fashion around a flexible plastic tube. A cable of this type construction approximately 18" long is employed between the 1st and 2nd video amplifiers.

2nd Video Amplifier — In the grid circuit of the 2nd video amplifier, R8 (1.5K) and R9 (2.2K) in parallel present a net resistance of approximately 900 ohms. This in series with R7 (1.8K) results in a total resistance of 2700 ohms which is correct to properly terminate the output of the delay line. Correct termination at both ends of the delay line is essential to eliminate line reflections and obtain maximum output. Correct termination at the input end of the line is provided by R6 (2.7K).

The Y contrast control serves to adjust the amplitude of the signal voltage fed to the grid of the 2nd video amplifier. As indicated on figure 7, it is ganged with the color contrast control so that brightness and saturation are varied simultaneously. A low impedance path from the bottom of the Y contrast control to the 6U8 cathode is provided by C1.

Optimum high frequency response is provided by the 6U8 cathode cir-

cuit components (C2 and R9), which cause less circuit degeneration at the higher frequencies, and the series peaking coil (L3) at the output of the delay line. In the 6U8 plate circuit, the series peaking coil (L4) and its damping resistor (R10) contribute also to the formation of the proper passband.

The output of the 2nd video amplifier which consists of video brightness (Y) information is applied to the matrix section where it is combined with chrominance signals from the circuits not yet described. It should be noted that this signal contains all information necessary for black and white reception and is, in fact, utilized for this purpose when a black and white transmission is being received.

For color reception, I and Q chrominance signals are applied to the matrix where they combine with the Y signal. The circuits that deal with these signals will be discussed in the next issue of Service News.

Basic material for this series of articles has been provided by K. F. Febling, Color Training Specialist, Teletest Service Department.

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